Special Well Construction and Abandonment Procedures for Pinal Creek Water Quality Assurance Revolving Fund Site

Arizona Department of Water Resources

Hydrology Division
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SPECIAL WELL CONSTRUCTION AND ABANDONMENT PROCEDURES FOR

PINAL CREEK WQARF SITE

INTRODUCTION

The Arizona Department of Water Resources (ADWR) has adopted rules governing minimum well construction standards. The rules are found in Title 12, Chapter 15, Article 8 of the Arizona Administrative Code R12-15-801 through R12-15-852. These rules specify the design, procedures, and materials that must be used to drill or abandon a well in Arizona and are enforced by ADWR. The rules are compiled in ***Statutes and Rules Governing Minimum Well Construction Standards and the Licensing of Well Drillers*** (ADWR, 2006). One of the purposes of the minimum well construction standards is to ensure the integrity of the sanitary surface seal and prevent vertical cross-contamination within an aquifer or between aquifer layers.

Special well construction considerations are necessary at sites with mineralized or contaminated groundwater (A.A.C. R12-15-812(B)), such as Water Quality Assurance Revolving Fund (WQARF) sites. The Pinal Creek Group (PCG) noted that special well construction and abandonment procedures are needed within the Pinal Creek WQARF site to protect groundwater in the portion of the Gila Conglomerate that is not currently impacted from the contaminated groundwater in the alluvial aquifer or upper portion of the Gila Conglomerate. As stated by PCG, "wells that penetrate the alluvial aquifer have the potential to encounter acidic groundwater, whereas groundwater in wells in the Gila Conglomerate is unlikely to be acidic" and "wells in shallow Gila Conglomerate close to the alluvial aquifer are most likely to be exposed to neutralized groundwater with elevated concentrations of T.D.S." The Gila Conglomerate is the main source of drinking water in the area.

This document specifies and describes special well construction standards and abandonment procedures for all new water supply, monitoring, and groundwater capture wells in the Pinal Creek WQARF site. The standards apply to groundwater capture wells that are screened in both the contaminated alluvial aquifer and the contaminated upper Gila Conglomerate. Figure 1 shows the Pinal Creek WQARF site and the area for which special well construction standards and abandonment procedures apply. These special standards are consistent with established minimum well construction standards.

Well construction standards and abandonment procedures are established for the following six types of well/aquifer conditions found at the Pinal Creek WQARF site are identified below:

TYPE I. Wells installed through (fully penetrating) or adjacent to the contaminated alluvial aquifer and screened in the Gila Conglomerate

TYPE II. Wells installed in the Gila Conglomerate (no alluvial aquifer present) where the upper portion of the conglomerate is contaminated

TYPE III. Wells installed in the Gila Conglomerate (no alluvial aquifer present) where the upper portion of the conglomerate is not contaminated

TYPE IV. Wells installed through mine tailings or other mine waste

TYPE V. Wells installed in uncontaminated bedrock no alluvium or Gila Conglomerate present

TYPE VI. Groundwater capture wells installed through or adjacent to the contaminated alluvial aquifer and into the contaminated upper Gila Conglomerate (and screened across both aquifers).

To expedite the review process, a well construction diagram noting the type of well (Type I through Type VI) shall be submitted by the applicant to ADWR at the time a Notice of Intent to Drill or Notice of Intent to Abandon a well is submitted.

WELL INSTALLATION PROCEDURES

Wells Installed Through or Adjacent to the Contaminated Alluvial Aquifer and Screened in the Gila Conglomerate (TYPE I)

All wells drilled through or adjacent to the contaminated alluvial aquifer, and screened in the Gila Conglomerate, except Type VI groundwater capture wells, shall be constructed as shown in Figure 2. Adjacent is defined as within 100 feet of the boundaries of the alluvial aquifer or within a zone of influence of the contaminated aquifer. The borehole depth, borehole diameter, and casing diameter may vary; however, the relationships between well construction specifications shall remain constant. To prevent vertical cross-contamination, an outer steel conductor casing must be installed from a minimum of one (1) foot above the land surface, through the contaminated alluvium to a minimum depth of twenty-five (25) feet into the Gila Conglomerate or any other water-producing strata. With the exception of monitor wells and piezometers, the well shall not be installed with screened intervals open to contaminated groundwater.

Acid-resistant cement (pozzolanic cement) grout shall be used between the borehole wall and the outer conductor casing to grout the outer conductor casing in place. Refer to Table 1 - Annular Seal Materials and Mixtures for the proper mixing ratios of materials. The thickness between the borehole and the outer conductor casing shall be a minimum of two (2) inches to ensure sufficient room to emplace annular seals (EPA., 1991; Driscoll, 1986).

In all cases, the well shall be designed so that the top of the screened interval is a sufficient depth below the contact between the alluvial aquifer and the Gila Conglomerate or any other contaminated water-producing strata. Sufficient depth is defined as no less than 120 feet unless a demonstration can be made that would warrant a variance from this requirement. The minimum depth is based upon PCG's recommendation and should prevent migration of potentially contaminated groundwater and reduce the risk of vertical leakage across hydrogeologic contacts. This standard does not apply to monitor wells, piezometers, and capture wells.

As stated in the AAC R12-15-811(a)(2), all casing joints shall be waterproof to prevent degradation to the water supply. Threaded flush joints are preferred in areas of known groundwater contamination. The casing material must be chemically inert with contaminants of concern within the groundwater (EPA, 1991).

An interval of fine silica sand (less than 0.25 millimeter diameter), approximately three (3) to five (5) feet thick, shall be placed over the filter pack material to form a barrier between the annular grout material and the filter pack and prevent grout from bleeding

into the filter pack. A high-solids (greater than 15 percent) bentonite grout or acid-resistant cement grout shall be installed to completely fill the well annulus from the top of the fine sand to five (5) feet below land surface, at which point acid-resistant cement grout shall be installed to fill the annulus to ground surface.

Wells Installed in Gila Conglomerate (No Alluvial Aquifer Present) Where the Upper Portion of the Conglomerate is Contaminated (TYPE II)

Wells drilled in the Gila Conglomerate where alluvium is not present and the upper portion of the aquifer is contaminated shall be constructed similar to Type I well construction standards in all details except that the installation of the outer steel conductor casing is optional. If the well is drilled between groundwater zones which differ significantly in water quality, the drilling procedure must minimize the migration of contaminated water from each groundwater zone to lessen vertical cross-contamination during drilling as required (A.A.C. R12-15-812(B)). Figure 3 shows a schematic for wells to be drilled under these conditions.

Wells Installed in Gila Conglomerate (No Alluvial Aquifer Present) Where the Upper Portion of the Conglomerate is not Contaminated (TYPE III)

Well construction where Type III conditions are present shall be similar to Type II conditions through upper portions of the Gila Conglomerate that are contaminated. Special consideration should be given for wells installed only in Gila Conglomerate to place the top of the screen deep enough to minimize the potential for drawing in water high in Total Dissolved Solids (TDS). Figure 3 shows a schematic for wells to be drilled under these conditions. The 120 foot minimum depth as shown in Figure 3 does not apply for Type III wells.

Wells Installed Through Mine Tailings or Other Mine Waste (TYPE IV)

Well construction where Type IV conditions are present shall follow the requirements of wells drilled through the alluvial aquifer (Type I) in all details, as shown in Figure 2. If the well does not penetrate any other groundwater zone(s), the outer steel conductor casing is optional. The drilling procedure must minimize the migration of contaminated water from each groundwater zone to lessen vertical cross-contamination during drilling as recommended by EPA (1991).

Well Installed in Uncontaminated Bedrock (No Alluvium or Gila Conglomerate Present) (TYPE V)

Wells installed in areas where no saturated alluvium or Gila Conglomerate are present and in areas with unimpacted bedrock units, including all units predating the Gila Conglomerate (Escabrosa/Martin Limestone, Dripping Springs Quartzite, Dacite, Diabase, etc.), shall be constructed in accordance with A.A.C. R12-15-812(B).

Groundwater Capture Wells Installed Through or Adjacent to Contaminated Alluvial Aquifer and Into the Contaminated Upper Gila Conglomerate and Screened Across Both Aquifers (TYPE VI)

All capture wells drilled through or adjacent to the contaminated alluvial aquifer shall be generally constructed as shown in Figure 4. Adjacent is defined as within 100 feet of the boundaries of the alluvial aquifer or within a zone of influence of the contaminated aquifer. The total depth, borehole diameter, and casing diameter may vary; however, the relationships between well construction specifics shall remain constant. Vertical cross contamination shall be prevented by restricting the depth of the screen interval to the contaminated Upper Gila Conglomerate. The screen interval shall not extend into uncontaminated Gila Conglomerate. If the thickness of the contaminated Gila Conglomerate is unknown, the screen shall be installed no more than 30 feet below the alluvium / Upper Gila Conglomerate contact.

As required by A.A.C. R12-15-811(B)(2), all joints shall be waterproof to prevent leakage of fluids. Threaded flush joints are preferred within areas of known groundwater contamination (EPA, 1991). The casing material must be chemically inert with contaminants of concern within the groundwater as recommended by EPA (1991).

At least three to five feet of fine silica sand (less than approximately 0.25 millimeter diameter) shall be placed over the filter pack material to form a barrier to the slurry used to fill the annular space. High-solids bentonite grout shall be used to fill the annular space from the top of the fine silica sand interval to 20 feet below land surface, at which point an acid-resistant cement (pozzolanic cement) shall be used to complete the grouting of the annulus space to the land surface. Figure 4 shows a schematic for capture wells to be drilled under these conditions.

WELL ABANDONMENT PROCEDURES

Abandonment Procedures for Wells Installed Through or Adjacent to the Contaminated Alluvial Aquifer and Screened in the Gila Conglomerate (TYPE I)

Wells drilled through or adjacent to the contaminated alluvial aquifer and screened in the Gila Conglomerate shall be abandoned in conformance with the requirements of A.A.C.R12-15-816. In addition, the well shall be filled completely with a high-solids bentonite grout from the bottom of the well to ten (10) feet above the highest known water level within the well, at which point an acid-resistant cement (pozzolanic cement) shall be used to complete the abandonment. The depth of the alluvium/Gila Conglomerate contact must be demonstrated to ADWR prior to abandonment through well logs and/or video or geophysical methods. The demonstration shall be relative to well design and submitted during the application process. No perforating or well casing removal shall be required for any wells originally constructed in compliance with the requirements specified in this document. Additional guidance for well abandonment is available through the American Society of Testing and Materials (ASTM, 1992).

Abandonment Procedures for All Other Wells within the WQARF Site (All Other TYPES)

No perforating or well casing removal shall be required for any wells originally constructed in compliance with the requirements specified in this document. If the well was not constructed in compliance with these standards, the casing shall be pulled if this can be accomplished. If the casing cannot be pulled, either the well shall be overdrilled or the casing shall be perforated over its entire length with a minimum of two (2) cuts per foot and pressure-grouted.

All wells shall be filled completely with a high-solids bentonite grout from the bottom of the well to ten (10) feet above the highest known water level of the well, at which point an acid-resistant cement (pozzolanic cement) shall be used to complete the abandonment to the land surface.

The estimated volume of grout material to be used to complete the abandonment shall be specified on the “Notice of Intent to Abandon a Well” form submitted to ADWR. The actual volume of grout materials used shall be reported to ADWR on the “Well Abandonment Completion Report (ADWR form 55-58) within thirty (30) days after the well abandonment is complete.

REFERENCES

ADWR, 2006. Statutes and Rules Governing Minimum Well Construction Standards and the Licensing of Well Drillers. Arizona Department of Water Resources. January 1, 2006.

ASTM, 1992. Standard Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities, D5299-92. American Society for Testing and Materials, West Conshohocken, PA.

Driscoll, F.G., 1986. Groundwater and Wells. Johnson Filtration Systems Inc., St. Paul, Minnesota.

EPA, 1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. United States Environmental Protection Agency, Office of Research and Development, EPAJ600/4-89/034. March 1991.

TABLE

Table 1. Annular Seal Materials and Mixtures

Category	Specific Material	Mixing Ratio		Special Considerations
		Solids	Water	
Cement	Acid Resistant Cement (Pozzolanic Cement)	One sack of cement (94 lb.) and seventy-four (74) lbs pozzolans (fly-ash, perlites, etc.) 2 to 6% of bentonite by weight is needed if perlites are used	Not more than ten (10) gallons of water per sack of cement	Typically used in areas where low pH groundwater is encountered. If perlites are used, bentonite is needed to keep perlites from floating. Chemical admixtures and plastizers may be used to reduce viscosity. This mixing ratio is in accordance with ASTM D5299.
Bentonite	High-Solids Bentonite Grout (dry powder)	Fifteen (15) lbs. dry bentonite powder	Seven (7) gallons	Materials or mixtures must be emplaced under sufficient pressure to fill all voids, including all annular space(s), and displace water from the well. A tremie pipe must be used to emplace the grout from the bottom up. The end of the tremie pipe must remain in close proximity to the rising grout surface, as the grout is pumped into the well.

FIGURES

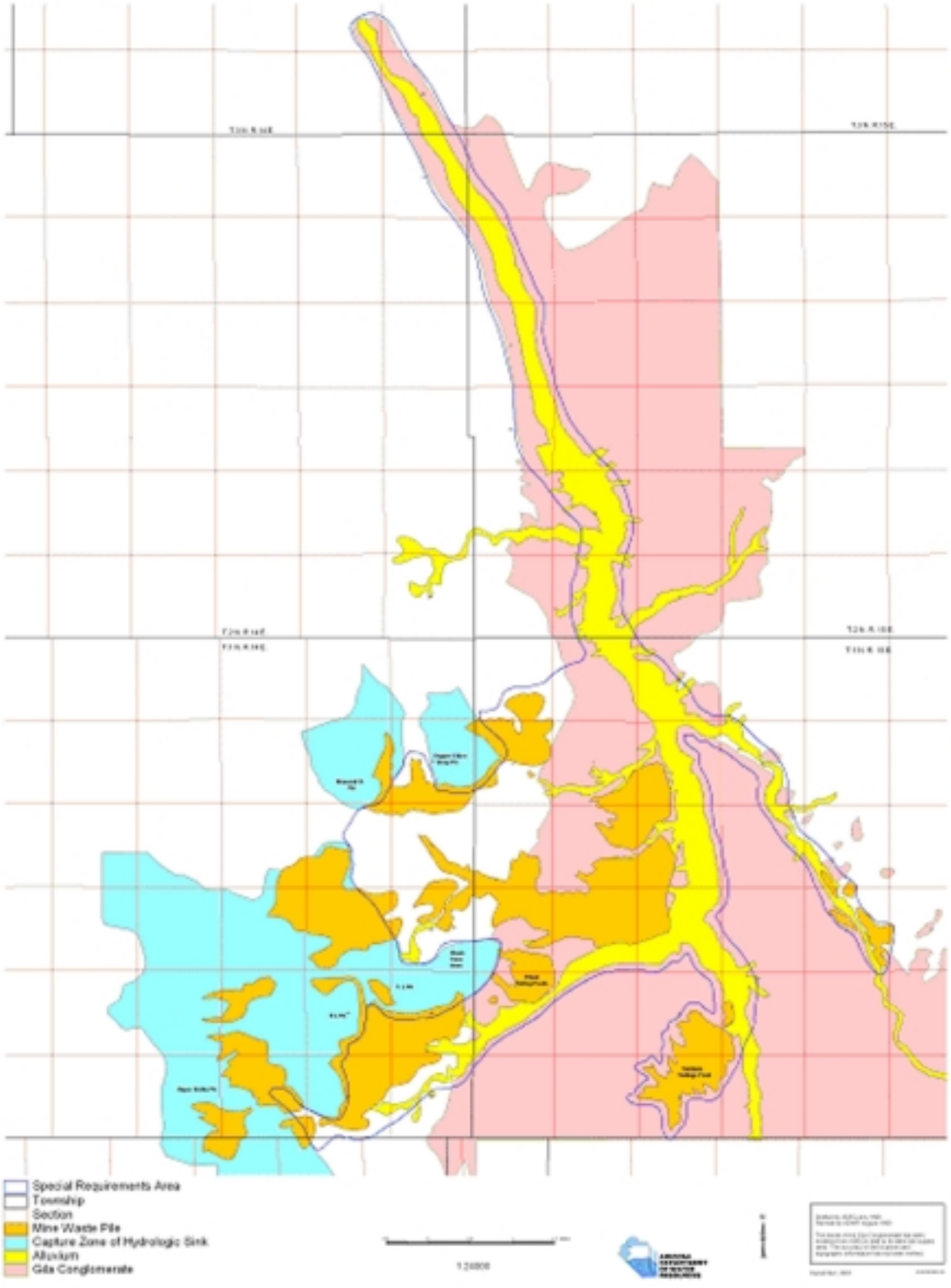

Figure 1.
Pinal Creek WQARF Site
Delineation of Area Where Special Well Construction &
Abandonment Requirements are Applicable

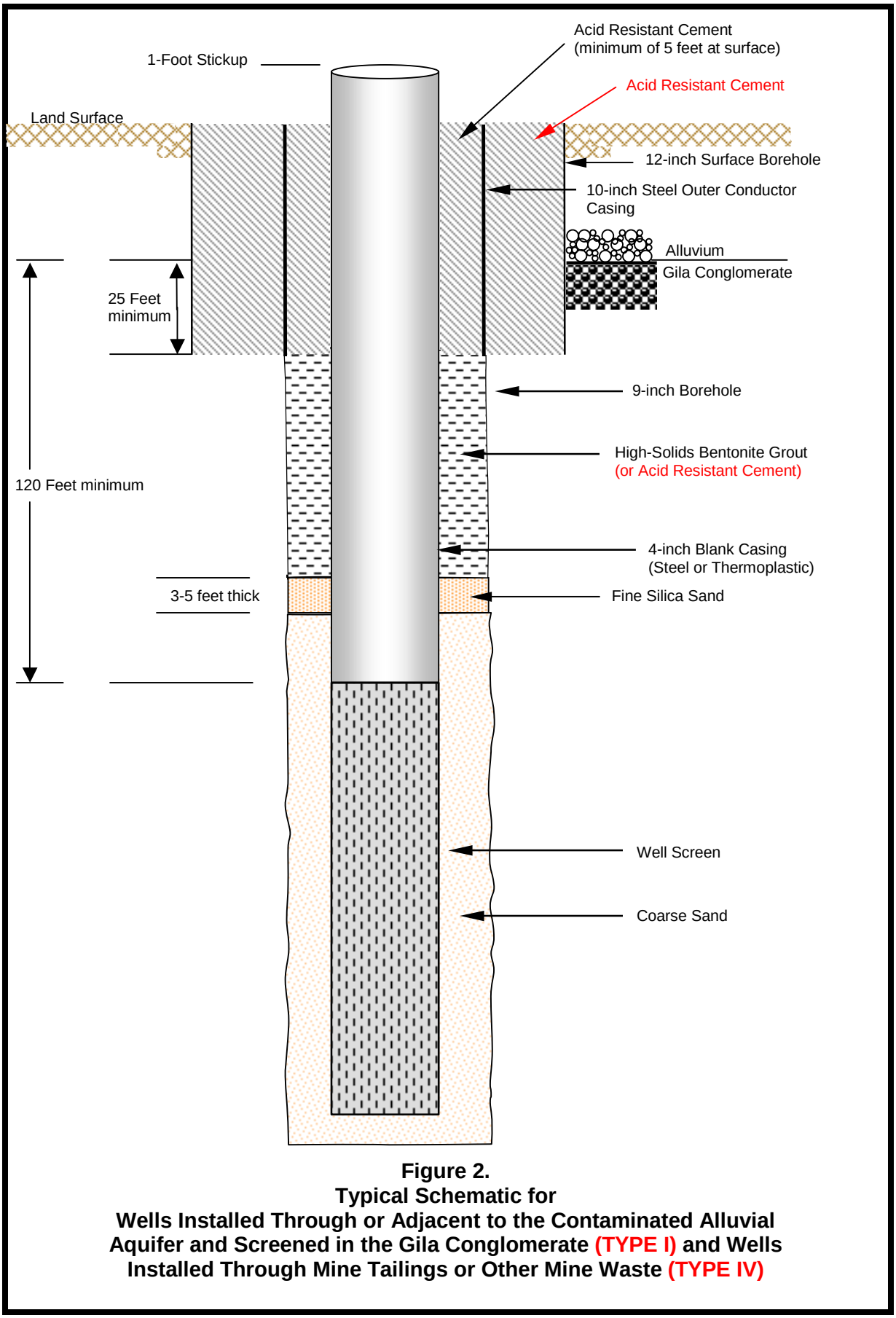

Figure 2.
Typical Schematic for
Wells Installed Through or Adjacent to the Contaminated Alluvial Aquifer and Screened in the Gila Conglomerate (TYPE I) and Wells Installed Through Mine Tailings or Other Mine Waste (TYPE IV)

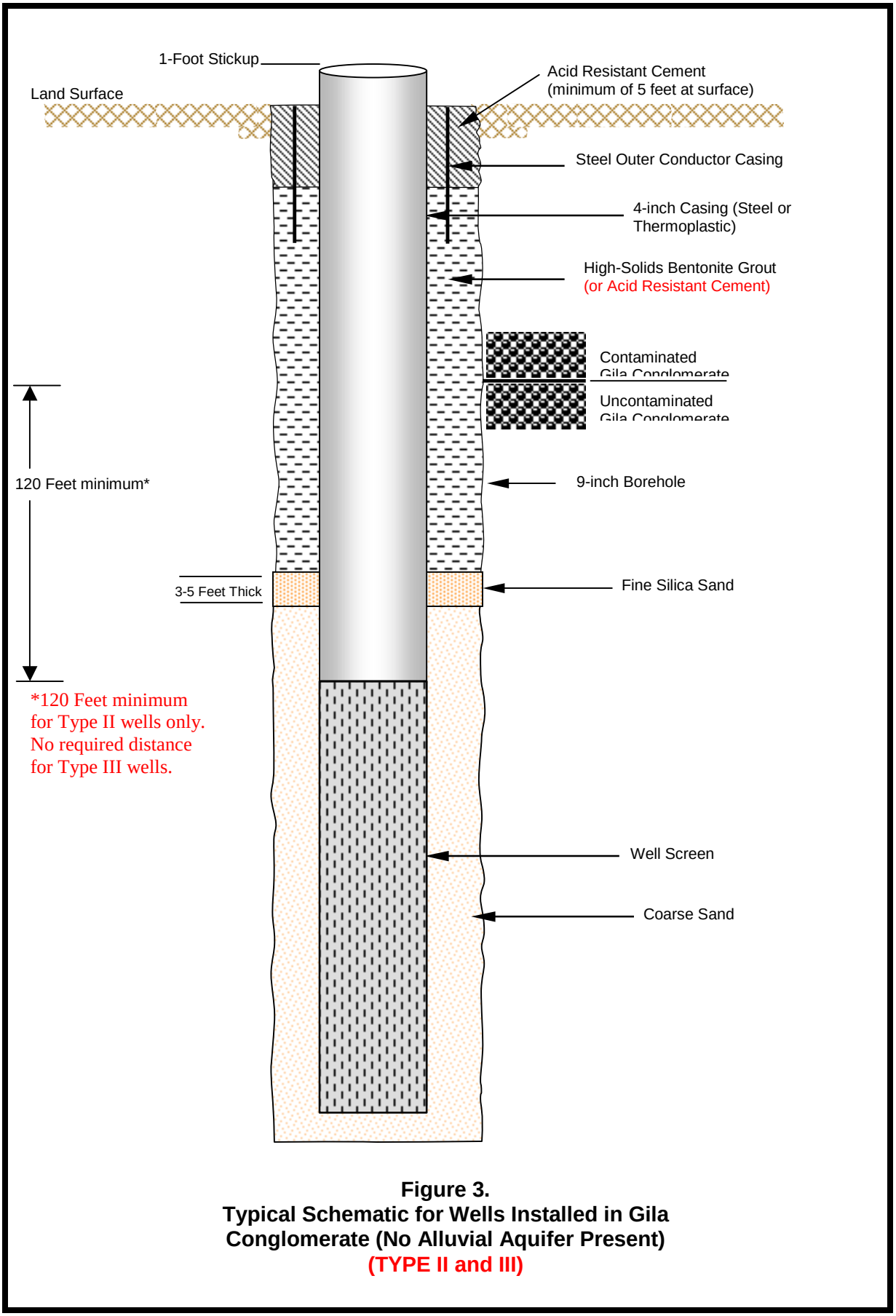

Figure 3.
Typical Schematic for Wells Installed in Gila Conglomerate (No Alluvial Aquifer Present)
(TYPE II and III)

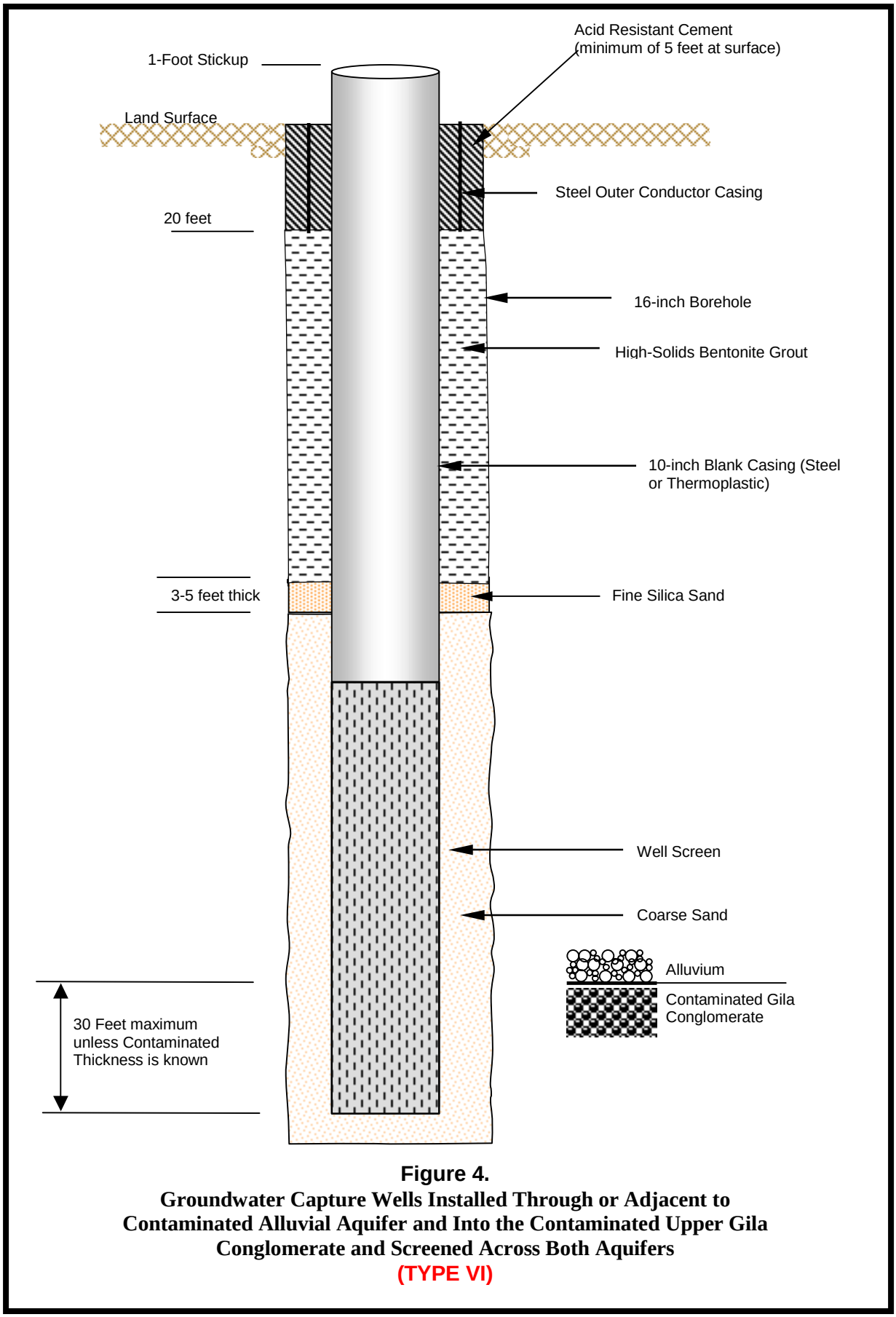

Figure 4.
Groundwater Capture Wells Installed Through or Adjacent to Contaminated Alluvial Aquifer and Into the Contaminated Upper Gila Conglomerate and Screened Across Both Aquifers
(TYPE VI)